CARDIOTHORACIC TRANSPLANTATION

PREIMPLANTATION RETROGRADE PNEUMOPLEGIA IN CLINICAL LUNG TRANSPLANTATION

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Objective: Retrograde pneumoplegia seems to improve early graft function in experimental and clinical lung transplantation. We evaluated the role of retrograde flushing in addition to antegrade pneumoplegia in clinical lung transplantation. **Methods:** Fourteen patients undergoing lung transplantation were randomized into 2 groups: in group I we performed antegrade pulmonary artery flushing with alprostadil (prostaglandin E₁) and modified Euro-Collins solution at the time of retrieval. In group II additional retrograde flushing through the pulmonary veins was performed at the back table, before reimplantation. Hemodynamic variables, mean airway pressure, and blood gas analysis were monitored at different time points. Postoperative volumetric monitoring was performed to assess extravascular lung water. The reimplantation response was assessed by a radiographic score; extubation time and intensive care unit stay were recorded. **Results:** During retrograde flushing, blood and clots coming out from the pulmonary artery were observed; 2 lungs harvested from a donor with multiple bone fractures had fat emboli in the retrograde perfusate. Hemodynamic monitoring did not demonstrate any difference between the 2 groups. The ratio of arterial oxygen tension to inspired oxygen fraction, extravascular lung water, duration of intubation, and length of stay in the intensive care unit were improved in group II, but the differences did not reach statistical significance. Intrapulmonary shunt fraction was significantly improved in group II at each time point ($P = .02$), as well as indexed alveolar-arterial oxygen tension gradient ($P = .04$), mean airway pressure ($P = .04$), and chest x-ray score ($P = .03$). **Conclusions:** Preimplantation retrograde flushing is not detrimental and helps to improve early graft function. (J Thorac Cardiovasc Surg 1999;118:107-14)

Lung transplantation is actually considered an effective treatment for many types of end-stage lung disease; improved results are related to amelioration of sur-

gical technique, postoperative care, immunosuppression, and lung preservation. However, even in technically uncomplicated transplantations, the function of the transplanted lung may be transiently and sometimes critically deranged in the early postoperative period as a result of multiple causes; in fact, injury to the donor lung may occur before the death of the donor or during ischemia, implantation, and reperfusion.¹ A number of different techniques for lung preservation have been proposed in experimental and clinical lung transplantation.² They have all been successful, but none is ideal. Antegrade pulmonary artery flushing with modified Euro-Collins solution or University of Wisconsin solution, mild hyperinflation, and cold storage is currently the most widely used method. However, it presents a number of drawbacks: Pulmonary arterial vasoconstrict-

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Fig 1. **A**, Chest x-ray film on day 2 of a patient in group I receiving DLT for cystic fibrosis. The reimplantation response is visible in both lungs with a prevalence on the left side, which was transplanted first. **B**, Chest x-ray film on day 2 of a patient in group II receiving DLT for cystic fibrosis. Virtually no reimplantation response is shown in either lung.

tion occurs^{3,4} and necessitates pretreatment of the donor with bolus injection of prostaglandins⁵; the bronchial circulation is not reached by the perfusate; clots and fat or brain tissue emboli,⁶⁻⁸ especially in donors with major trauma and multiple bone fractures, may jeopardize the uniformity of the flushing and impair graft reperfusion. Retrograde pneumoplegia through the pulmonary veins can flush both the pulmonary and bronchial circulations and may help to eliminate the residual blood and macroscopic clots or other emboli obstructing the pulmonary vessels. This technique has been used in experimental and clinical lung transplantation and seems to offer better lung preservation with less edema and improved oxygenation.⁹⁻¹¹

We evaluated the role of retrograde pulmonary artery flushing in addition to antegrade pneumoplegia in clinical lung transplantation.

Table I. Donor population data

	Group I	Group II
Age (y)	27.2 ± 10.2	27.4 ± 8.4
Smoking	3/7 (42%)	4/7 (57%)
Hypotension*	2	2
Dopamine dose (μg/kg/min)	7 ± 4	8 ± 4
Pao ₂ (mm Hg)†	502 ± 25	440 ± 32
ICU stay (h)	2.2 ± 0.57	2.7 ± 1.1

Pao₂, Arterial oxygen tension; ICU, intensive care unit.

*Number of episodes of systemic hypotension (<80 mm Hg) requiring resuscitation before donation.

†Inspired oxygen fraction = 1.

Patients and methods

During a 10-month period, 14 consecutive patients undergoing lung transplantation were enrolled in our study and randomized into 2 groups. There were 6 sequential double lung transplants (DLT) and 1 single lung transplant (SLT) in each group; in group I we operated on 6 patients with cystic fibrosis and 1 with emphysema. In group II 6 patients had cystic fibrosis and 1 had idiopathic pulmonary fibrosis. The mean age of patients was 35.8 ± 10.6 years in group I and 32.8 ± 10 years in group II. In group I we performed antegrade pulmonary artery flushing with a bolus injection of alprostadil (prostaglandin E₁; 500 ng) and modified Euro-Collins solution (60 mL/kg) at the time of retrieval only; to keep a relatively high alprostadil concentration in the donor lungs, another 500 ng was mixed with the flush solution. In group II additional retrograde flushing via the pulmonary veins with modified Euro-Collins solution (30-40 mL/kg) was performed in the recipient operating room, before implantation, with the lungs still inflated. No alprostadil was added to the retrograde flush. After retrograde pneumoplegia, in case of SLT the donor lung was immediately reimplanted; in case of DLT the first lung was implanted immediately and the second one was stored in the ice chest and retrieved only after completion of the anastomoses of the first lung. The quantitative data of all the donors (blood gas analysis, duration of stay in the intensive care unit [ICU], cause of death, chest radiograph, smoking habit, number of episodes of hypotension, and dopamine dose) and ischemic times were recorded. The surgical technique for in situ separate extraction of the heart and the double lung block was standard. No recipient required the use of cardiopulmonary bypass during the operation. Postoperative care was the same for all patients: fluid restriction with high doses of diuretics, inotropic support, antibiotics, and the immunosuppressive regimen were always ordered by the same team. Standard hemodynamic monitoring (cardiac index, central venous pressure, mean pulmonary artery pressure, mean arterial pressure, pulmonary capillary wedge pressure, pulmonary vascular resistance indexed, systemic vascular resistance indexed, intrapulmonary shunt fraction), indexed alveolar-arterial oxygen (A-aDO₂/PO₂) gradient, blood gas analysis, and mean airway pressure were monitored

Table II. Standard hemodynamic monitoring after lung transplantation in group I and II

	0	6	1	12	18	36	48	P value
Mean arterial pressure (mm Hg)								
Group I	89 ± 11	82 ± 13	86 ± 13	88 ± 6	88 ± 10	96 ± 10	99 ± 9	.2
Group II	90 ± 14	83 ± 13	85 ± 13	98 ± 7	97 ± 14	98 ± 7	112 ± 12	
Cardiac index (L · min · m ⁻²)								
Group I	4.2 ± 1.4	4.4 ± 1.2	4.7 ± 1	4.9 ± 1	5 ± 1	5.3 ± 1.3	5.4 ± 0.7	.4
Group II	4.6 ± 1	4.9 ± 0.5	5.3 ± 1.2	5.1 ± 1	5.2 ± 1.4	5.5 ± 1	5.2 ± 1	
Central venous pressure (mm Hg)								
Group I	11 ± 7	10 ± 4	11 ± 4	11 ± 3	12 ± 4	10 ± 4	9 ± 4	.3
Group II	7 ± 4	9 ± 2	9 ± 3	10 ± 3	9 ± 3	11 ± 3	10 ± 3	
Systemic vascular resistance indexed (dynes · sec · cm ⁻⁵ · m ⁻²)								
Group I	1655 ± 467	1406 ± 702	1305 ± 379	1196 ± 397	1413 ± 376	1415 ± 691	1251 ± 547	.5
Group II	1674 ± 479	1336 ± 346	1430 ± 544	1488 ± 437	1499 ± 397	1480 ± 364	1624 ± 493	
Mean pulmonary artery pressure (mm Hg)								
Group I	23 ± 5	25 ± 6	26 ± 6	28 ± 7	26 ± 6	25 ± 6	24 ± 4	.5
Group II	24 ± 4	25 ± 3	26 ± 4	23 ± 6	28 ± 6	29 ± 6	28 ± 7	
Pulmonary capillary wedge pressure (mm Hg)								
Group I	14 ± 5	15 ± 5	17 ± 5	16 ± 4	17 ± 5	14 ± 2	14 ± 4	.2
Group II	12 ± 3	13 ± 1	15 ± 6	12 ± 5	14 ± 5	15 ± 3	15 ± 6	
Pulmonary vascular resistance indexed (dynes · sec · cm ⁻⁵ · m ⁻²)								
Group I	193 ± 114	174 ± 139	161 ± 78	216 ± 123	182 ± 98	191 ± 55	112 ± 60	.2
Group II	268 ± 106	229 ± 76	191 ± 78	173 ± 39	238 ± 113	143 ± 89	212 ± 105	

The variables were measured at arrival in the intensive care unit (time 0) and after 6, 12, 18, 24, 36, and 48 hours. *P* values refer to the “between-groups” analyses.

after transplantation, after arrival in the ICU (time 0), and after 6, 12, 24, 36, and 48 hours. Postoperative volumetric monitoring (thermal green dye indicator dilution COLD system) (PULSION Medical Systems; Munich, Germany) was performed to assess extravascular lung water. The degree of reimplantation response at chest radiography was evaluated by means of the scoring system proposed by the St Louis group¹²; each of 4 lung regions on chest radiographs (perihilar, apical, lateral, and basilar) was assigned a numeric value (0 = normal lung; 1 = minimal interstitial infiltrate that does not obscure lung vessels; 2 = moderate interstitial infiltrate that partly obscures the lung vessels with or without air bronchograms; 3 = extensive alveolar infiltrate that completely obscures the lung vessels with or without air bronchogram). The total lung score for each lung (from 0 to 12) was the sum of the 4 regions and was recorded for each of the first 3 postoperative days. Extubation time and ICU stay were also recorded. At the end of the operation, before the chest was closed, samples of the transplanted lungs were taken with a GIA stapler (Ethicon, Inc, Somerville, NJ) and bovine pericardial strips (Peri-Strip surgical tape; Bio-Vascular, Inc, St Paul, Minn) to buttress the suture line.

Data were collected and managed with the aid of a commercial spreadsheet software package (Microsoft Excel 97, version 6.0, Redmond, Wash). All data were expressed as mean ± standard deviation of the mean. The data of the 2 groups were compared with the analysis of variance for repeated measures. Statistical analysis was performed with the GLM procedure of the SAS package (version 6; SAS Institute Inc, Cary, NC).

Results

All patients underwent successful transplantation and were discharged from the hospital. In group I, 4 donors came from car accidents, 1 had committed suicide, and 2 had brain hemorrhage; in group II, 3 donors came from car accidents and 4 had brain hemorrhage. One donor in each group was marginal (Pao₂ < 350 mm Hg and unilateral lung contusion). The data of the donor population in each group are reported in Table I. The ischemia time for SLT and the first lung of DLT was 271 ± 40 minutes and 253 ± 34 minutes for groups I and II, respectively; for the second lung it was 383 ± 40 minutes and 383 ± 32 minutes, respectively. During retrograde flushing, blood and clots came out from the main pulmonary artery in all lung blocks; 2 lungs harvested from a donor with multiple bone fractures had macroscopic fat emboli in the retrograde perfusate. Most of the posterior segments of the lower lobes were less perfused after antegrade flushing; retrograde flushing improved whitening of the donor lungs by washing out the residual blood. The postoperative cumulative chest x-ray score was significantly better in group II (mean scores for group I and group II: 7.2 ± 1.2 and 2.3 ± 0.72, respectively; *P* = .03) (Fig 1). The mean intubation time was 51 ± 31 hours for group I and 31.7 ± 10.7 hours for group II; the mean stay in the ICU was 6.5 ± 2.5 days and 5.2 ± 2.3 days, respectively. Standard hemodynamic monitoring (mean pulmonary

Fig 2. The ratio of arterial oxygen tension to inspired oxygen fraction (PaO_2/FiO_2) in groups I and II.

Fig 3. Extravascular lung water indexed (EVLWI) (mL/kg) in groups I and II.

Fig 4. Alveolar-arterial oxygen gradient indexed to PO_2 ($A-aDO_2/PO_2$) in groups I and II.

artery pressure, mean arterial pressure, central venous pressure, cardiac index, pulmonary artery wedge pressure, systemic vascular resistance indexed, and pulmonary vascular resistance indexed) failed to demonstrate any significant difference between the 2 groups (Table II). The ratio of arterial PO_2 to inspired oxygen fraction (Fig 2) was improved in group II at each time point, as well as extravascular lung water index (Fig 3), but the difference did not reach statistical significance, probably because of the small sample size and high standard deviation. However, extravascular lung water index was significantly increased in group I during the operation, immediately after completion of implantation (17 ± 2.6 vs $11.8 \text{ mL/kg} \pm 2.8 \text{ mL/kg}$; $P = .008$). A statistically significant improvement was present in group II in terms of indexed alveolar-arterial oxygen gradient (Fig 4), intrapulmonary shunt fraction (Fig 5), mean airway pressure (Fig 6), and chest x-ray score. Histologic examination showed a mild reduction of alveolar edema in group II patients (Fig 7).

Discussion

Early graft dysfunction is an ill-defined clinical entity resulting from a multifactorial lung injury starting within the donor and continuing during organ harvesting, storage, implantation, and reperfusion. Two clinical forms of nonimmunologically mediated damage are the so-called reimplantation response and primary graft failure.¹³ The first is manifested by patchy infiltrates resembling pulmonary edema, beginning on the first day and reaching a peak by day 3; it is usually associated with a mildly elevated alveolar-arterial oxygen gradient and a decrease in pulmonary compliance, but it appears to have minimal clinical impact. On the contrary, primary graft failure is associated with a significant morbidity and mortality, a marked decline in pulmonary function, and histologic features of diffuse alveolar damage. Early graft dysfunction may be related to several donor-acquired problems, such as pulmonary embolism (clots, fat, brain tissue), lung contusion, or inhalation; also the resuscitation maneuvers

Fig 5. Intrapulmonary shunt fraction (Q_s/Q_t) in patients in groups I and II.

Fig 6. Mean airway pressure ($mAwP$) in group I and group II patients.

(eg, massive blood transfusions, infusion of fluids) may contribute to the impairment of postoperative lung function.⁶ Our early experience with clinical lung transplantation forced us to face primary graft failure in 2 cases: autopsy showed multiple pulmonary embolism in 1 patient and fat embolism in the second patient. For this reason retrograde pneumoplegia was evaluated as a possible means to improve viability of the pulmonary circulation by reducing the risk of embolism, improving oxygenation, and preventing early dysfunction, especially when marginal donors or lungs from patients with multiple fractures are to be used. Experimental and clinical reports have shown that retrograde pulmonary flushing is not detrimental, can improve early lung function after transplantation, and reduces the radiologic appearance of the reimplantation response.⁹⁻¹¹

The pulmonary venous circulation is a low resistance–high capacity network; pneumoplegic solution administered through this route is straightforward and results in a rapid and uniform distribution of the solu-

Fig 7. Histologic studies of samples of lung parenchyma (hematoxylin and eosin stain; original magnification $\times 40$) taken in group I (**A**) and group II (**B**) before closure of the chest. A mild reduction in edema is evident in group II.

tion.¹⁴ Experimental studies have demonstrated that retrograde pneumoplegia can reach vascular segments that are not flushed by the forward route.¹⁵ Also, less well ventilated areas, such as the posterior segments of the lower lobes, are better flushed.^{14,16} Small clots can be removed by the back flow, and even if they remain

in place the distal vascular bed can be reached by the retrograde perfusate.

Retrograde pneumoplegia also has the advantage of flushing the bronchial circulation through the bronchopulmonary anastomoses, enhancing airway protection¹⁷; experimental lung transplantation has shown that retrograde flushing improves flow of the perfusate to the trachea and bronchi, whereas antegrade delivery improves flow to the lung parenchyma.¹⁴

Many indices have been used to test lung function after transplantation; gas exchange is generally considered a reliable indicator,¹⁸ because early damage may impair the lung exchange capacity without any morphologic alteration.¹⁹ We have shown a significant decrease of the intrapulmonary shunt fraction, alveolar-arterial oxygen gradient, mean airway pressure, and reimplantation response. The extubation time, ICU stay, ratio of arterial oxygen to inspired oxygen fraction, and extravascular lung water index improved in group II, even if the difference was not statistically significant. However, a few points deserve further comments: we expected that the improvement in chest x-ray score, indexed alveolar-arterial PO_2 gradient, intrapulmonary shunt fraction, and mean airway pressure would be paralleled by a significant decrease of pulmonary artery pressure, pulmonary vascular resistance, and extravascular lung water. The improved viability of the pulmonary circulation achieved with the retrograde flush should have resulted in a lower pulmonary artery pressure and pulmonary vascular resistance; however, the vasodilating drugs (nitric oxide, alprostadil) routinely administered immediately after reperfusion probably helped to eliminate any possible difference between the 2 groups. Also, the differences in terms of extravascular lung water, which were evident during the operation, were already reduced to nonsignificant levels after a few hours; however, the histologic studies of lung biopsy specimens taken before closing the chest confirmed a mild difference in alveolar edema between the 2 groups. These clinical findings confirm the experimental work published by other authors²⁰: in well-functioning lungs, the edema related to preservation progressively resolves during the first hours after reperfusion and no irreversible damage results. In DLT we may postulate that, along with the increased viability of the pulmonary vessels, retrograde flushing may have contributed to improved preservation of the second lung, which has prolonged ischemic time. This aspect of lung preservation should be further investigated by administering retrograde pneumoplegia at the time of harvesting. For this reason, we now administer retrograde pneumoplegia immediately after antegrade flushing at the time of lung

extraction. An additional advantage of this technique is that any possible emboli in the lung vasculature during antegrade pneumoplegia⁶ can be immediately washed out with the retrograde flushing.

Also, it is impossible to establish whether the differences between our 2 groups were simply related to the fact that the lungs in group II were flushed twice (in this case the possible role of a second antegrade flush should be investigated) or to the higher volume of total flushing solution delivered (5.5-6 L in group II vs 3.5-4 L in group I).

The small number of patients enrolled in our study does not allow us to draw definitive conclusions; however, along with the improvement in early lung function, substantiated by a better intrapulmonary shunt fraction, decreased alveolar-arterial oxygen difference, and reduced reperfusion edema at chest radiograph, we have observed blood and clots in the retrograde perfusate of all lung blocks and macroscopic fat emboli in the grafts harvested from donors with multiple bone fractures. However, we cannot postulate what their impact might have been without retrograde flushing.

Retrograde pneumoplegia is not detrimental and seems to improve early graft function. However, the specific role of this technique of preservation should be investigated by further experimental and clinical investigation.

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Discussion

Dr Stuart W. Jamieson (*San Diego, Calif*). First I would like to congratulate you on a very fine paper and what I think is probably a significant advance in pulmonary preservation techniques and our understanding of pulmonary preservation.

You remember, of course, that the first lung transplants were combined with the heart as heart-lung transplants, and at Stanford in 1981 and 1982, since we were so unsure about the safety of our preservation methods, the donor was brought into the adjacent operating room to minimize the ischemic time. You can imagine the difficulties this imposed, especially with the transport of bodies across state and even international borders. Clearly that was not going to be supportable in the long term. We then determined that the so-called modified Euro-Collins solution was a satisfactory solution to be used to flush the lungs and to get it cold without

inducing injury. That was used in our first clinical case in November 1982. That patient, incidentally, is still alive, 16½ years after the transplant, and is the longest surviving recipient of a lung transplant. When we used this solution in monkeys, we found that preservation of the lungs for 24 hours was tolerated. Although I am sure other solutions might equally well be used and perhaps be even better, it did not seem fruitful to pursue endlessly various minor variations of chemical composition. I believed then, and I still believe, that the essential factor is to get the lungs cold and keep them so until revascularization. In any event, our group has continued to use the same solution for the past 16 years, and we have now exceeded 8 hours of ischemia clinically without apparent injury.

Your paper explores a different topic, a different route of administration with the same solution. I think it is a useful contribution. The major point is the ability to flush out particulate material and clot, which in the donors is probably common. This will enhance preservation and also will improve reperfusion after implantation.

I have a number of questions. First, we found in the laboratory many years ago that the use of alprostadil was not helpful, and was possibly harmful, and we abandoned this 15 years ago. Are you sure that it is necessary?

Dr Venuta. A number of papers have been published in the international literature either in favor of or against the use of alprostadil. We have used alprostadil since our first lung transplant 7 years ago, and we have never had any problem. We believe that alprostadil should be used not only because its vasodilating activity compensates the action of the high potassium concentration in the preservation solution, but also because it has other features that can help to improve early lung function and prevent primary graft failure. In fact, we do not use alprostadil only at the time of harvesting; it is part of our routine protocol and is infused for at least 48 hours after the transplant. However, I am aware of the work that you published several years ago. I think the role of alprostadil should be further investigated, especially when retrograde pneumoplegia is used.

Dr Jamieson. I am always concerned about the term *pneumoplegia*, because, unlike in cardioplegia, the lung is not strictly paralyzed. Did you give the retrograde solution immediately after the antegrade flush solution in the donor operating room? I thought you said that you retrogradely flushed the solution when you brought the lungs to the recipient operating room.

Dr Venuta. You understood correctly; retrograde flushing was administered through the pulmonary veins (each vein separately) when the double lung block arrived at our institution.

Dr Jamieson. I would imagine that it would be most constructive to do it while the donor organs are being harvested, particularly if you wanted to fully revascularize and cool various areas of the lung that had been blocked by particulate debris. One other problem, of course, is that the 2 groups are not strictly compatible because, in effect, you gave your second group a second dose of flush solution, albeit backward.

Dr Venuta. I agree with you; it will certainly be more

effective to give both antegrade and retrograde flushing in the donor operating room, during harvesting, before taking the lungs out, or at the back table.

Dr Jamieson. I very firmly believe that maintenance of a low inspired oxygen fraction and maintenance of a high hematocrit value are keys to success in the early management of a lung transplant recipient. These are probably some of the most important factors in the assessment of your chest x-ray score. How carefully were you able to compensate for that in both your groups?

Dr Venuta. Fluid restriction is one of the key factors for success in lung transplantation. All patients of this study did well, and we did not observe any primary graft failure or other major problems. Fluid balance was carefully monitored; extravascular lung water was assessed by the COLD system during the operation and after the procedure, in the ICU. All patients were kept extremely dry, allowing a satisfactory hemodynamic performance. Extravascular lung water was higher immediately after reimplantation in the group not receiving retrograde flushing; however, 6 to 8 hours later, in the ICU, extravascular lung water started to decrease, and the differences between the 2 groups were kept at levels that were not statistically significant.

Dr Jamieson. I would like to congratulate you on your paper. You have made a useful contribution that I believe will become a routine measure.

Dr Vaughn A. Starnes (*Los Angeles, Calif*). I have two questions. First, a high proportion of your patients had cystic fibrosis. Was cardiopulmonary bypass used in all or some of them? How did you do the actual implant? Use or nonuse of bypass would make a difference, and if the techniques differed, there needs to be a variable control for it.

Dr Venuta. We never had to use cardiopulmonary bypass. At our institution bypass is not used electively. It is used only when required to maintain hemodynamic stability and oxygenation.

Dr Starnes. One of the issues that you discussed is that the first lung receives all the cardiac output. In the case of reimplantation, that predisposes it to pulmonary edema. Did you see that in either of your groups? I think the first chest x-ray film that you showed was more indicative of an implantation response.

Dr Venuta. There was a great difference in terms of reimplantation response on the chest x-ray film between group I and II patients. There was, as usual, a more important reimplantation response in the lung transplanted first, probably because it receives all the cardiac output during reimplantation of the second lung. Differences in terms of edema between the 2 groups were confirmed histologically, with biopsy specimens taken from the first reimplanted lung.

Dr Starnes. I have one other comment. Patients with cystic fibrosis come to the operating room in differing conditions. Some are in stable condition, and some have indulin infections. It is not until you start mobilizing the lungs that you observe the endotoxemic effect indicating whether ongoing infection is present. Did you see that in any of your patients? Did some of your patients have to have vasoconstrictors to support their systemic blood pressure during the operation, and was that controlled for?

Dr Venuta. Patients with cystic fibrosis may show different clinical parameters at the time of transplantation. One of our patients arrived already intubated and ventilated in the operating room. Our policy is to perform a careful toilette of the airway with the fiberoptic bronchoscope before starting the operation. We were able to aspirate 200 to 300 mL of dense secretions from the bronchial tree. Most of our patients required extended inotropic support during transplantation to avoid cardiopulmonary bypass. Transesophageal echocardiography was extremely useful to evaluate the morphology and contractility of the right and left sides of the heart during the procedure.

Dr Starnes. In no way do I want to de-emphasize the importance of the paper, because it makes a valuable point. You have treated a very difficult group of patients in whom there would be many factors to control for. It is probably difficult to control for all those in the cystic fibrosis population.

In our living donor series, when those lobes are flushed, there are frequently regions that do not perfuse well. They can be identified simply because they do not lose their color, and continuing the perfusion does not change that. If you then give retrograde pneumoplegia, most of those regions will be perfused, which implies that there may be some advantage in distribution of pneumoplegia with this technique. We have continued to do that.